

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property  
Organization  
International Bureau



(43) International Publication Date  
25 September 2003 (25.09.2003)

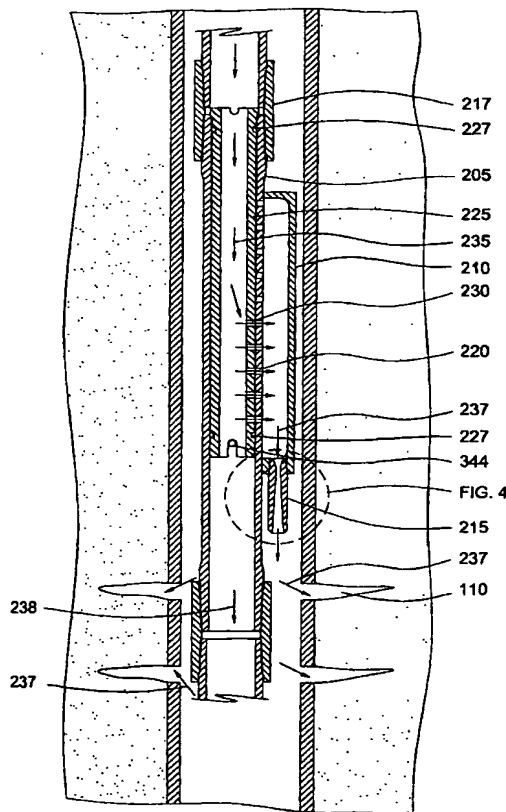
PCT

(10) International Publication Number  
**WO 2003/078791 A3**

- (51) International Patent Classification<sup>7</sup>: **E21B 43/24**, 41/00
- (21) International Application Number: PCT/US2003/007771
- (22) International Filing Date: 13 March 2003 (13.03.2003)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:  
10/097,448 13 March 2002 (13.03.2002) US
- (63) Related by continuation (CON) or continuation-in-part (CIP) to earlier application:  
US 10/097,448 (CIP)  
Filed on 13 March 2002 (13.03.2002)
- (71) Applicant (for all designated States except US): **WEATHERFORD/LAMB, INC.** [US/US]; 515 POST OAK BOULEVARD, SUITE 600, HOUSTON, TX 77027 (US).
- (72) Inventors; and  
(75) Inventors/Applicants (for US only): **HOWARD, William, F.** [US/US]; 338 South Amherst Drive, West Columbia, TX 77486 (US). **SIMS, Jackie, C.** [US/US]; 12003 Tanager, Houston, TX 77072 (US). **ROBINSON, Dudley, L.** [US/US]; 11617 Bob White, Unit #4, Houston, TX 77035 (US). **SCHMIDT, Ronald, W.** [US/US]; 2514 Cooling Breeze Drive, Richmond, TX 77469 (US).
- (74) Agent: **PATTERSON, William, B.**; Moser, Patterson & Sheridan LLP, 3040 Post Oak Boulevard, Suite 1500, Houston, TX 77056 (US).
- (81) Designated States (*national*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NI, NO, NZ, OM, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

[Continued on next page]

(54) Title: METHOD AND APPARATUS FOR INJECTING STEAM INTO A GEOLOGICAL FORMATION



(57) Abstract: The present invention generally provides a method and apparatus for injecting a compressible fluid at a controlled flow rate into a geological formation at multiple zones of interest. In one aspect, the invention provides a tubing string with a pocket and a nozzle at each isolated zone. The nozzle permits a predetermined, controlled flow rate to be maintained at higher annulus to tubing pressure ratios. The nozzle includes a diffuser portion, to recover lost steam pressure associated with critical flow as the steam exits the nozzle and enters a formation via perforations in wellbore casing. In another aspect, the present invention assures that the fluid is supplied uniformly to a long horizontal wellbore by providing controlled injection at multiple locations that are distributed throughout the length of the wellbore. In another aspect, the invention ensures that saturated steam is injected into a formation in a predetermined proportion of water and vapor by providing a plurality of apertures between a tubing wall and a pocket. The apertures provide distribution of steam that maintains a relative mixture of water and vapor. In another aspect of the invention, a single source of steam is provided to multiple, separate wellbores using the nozzle of the invention to provide a controlled flow of steam to each wellbore.



(84) Designated States (*regional*): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

**Declaration under Rule 4.17:**

— *of inventorship (Rule 4.17(iv)) for US only*

**Published:**

— *with international search report*

(88) Date of publication of the international search report:

15 January 2004

*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

# INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 03/07771

**A. CLASSIFICATION OF SUBJECT MATTER**  
 IPC 7 E21B43/24 E21B41/00

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)  
 IPC 7 E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, PAJ, WPI Data, TULSA

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 648 455 A (LUKE MIKE A) 10 March 1987 (1987-03-10)  abstract column 4, line 17-42 column 4, line 50-55 column 5, line 23-30 figures 1,3,4	1,3-10, 12-15, 23-25, 28,31-46
Y		2
Y	US 5 141 054 A (ALAMEDDINE BASSEM R ET AL) 25 August 1992 (1992-08-25) figure 3  --- -/-	2

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

\* Special categories of cited documents :

- \*A\* document defining the general state of the art which is not considered to be of particular relevance
- \*E\* earlier document but published on or after the international filing date
- \*L\* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- \*O\* document referring to an oral disclosure, use, exhibition or other means
- \*P\* document published prior to the international filing date but later than the priority date claimed

\*T\* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

\*X\* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

\*Y\* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

\*8\* document member of the same patent family

Date of the actual completion of the international search

16 July 2003

Date of mailing of the international search report

29/07/2003

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2  
 NL - 2280 HV Rijswijk  
 Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,  
 Fax: (+31-70) 340-3016

Authorized officer

Schouten, A

# INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 03/07771

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 141 055 A (CHIEN SZE-F00 ET AL) 25 August 1992 (1992-08-25) column 3, line 13 -column 4, line 2 figure 2 ---	1,3,28, 31
A	US 4 640 355 A (AULT JOSEPH W ET AL) 3 February 1987 (1987-02-03)  column 3, line 60 -column 4, line 9 figures 1,1A,1B ---	1,26,28, 33,36, 37,40
A	US 4 770 244 A (WEBB CHARLES H) 13 September 1988 (1988-09-13)  abstract column 3, line 9-29 figure 1 ---	1,26,28, 33,36, 37,40
A	SUZANNE GRISTON ET AL: "Field test of Tapered-Bore chokes for Steam Flow Control" SPE # 35677, 22 May 1996 (1996-05-22), pages 269-283, XP002248011 Introduction, page 269, column 2 figures 1,2 ---	1,26,28, 33,36, 37,40
A	US 4 646 828 A (ROBISON CLARK E ET AL) 3 March 1987 (1987-03-03)  abstract figure 1B -----	1,26,28, 33,36, 37,40

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US 03/07771

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 4648455	A	10-03-1987	NONE	
US 5141054	A	25-08-1992	NONE	
US 5141055	A	25-08-1992	NONE	
US 4640355	A	03-02-1987	NONE	
US 4770244	A	13-09-1988	NONE	
US 4646828	A	03-03-1987	CA 1274171 A1	18-09-1990
			US RE33614 E	18-06-1991
			US 5024274 A	18-06-1991